only. These doubts are well justified inasmuch as the true phase shifting is possibly of another magnitude; nevertheless the approach of the extreme of pressure oscillation earlier at the higher levels than at the lower appears to be real, as the phase shifting between Zugspitze and high Peissenberg (with respect to the Bavarian lowland) and between Säntis and Zurich agrees in direction and order of magnitude with that between Lindenberg at 3,000 meters and the surface. It may be seen therefrom how much more precise is the analytical than the customary graphic method for the investigation of periodic processes. In a horizontal direction there results a phase shifting from south to north in such a way that on Säntis (lat. 47° 15′) and on the Zugspitze (lat. 47° 25′) the extreme oscillation occurs about 10 days earlier than at the 3,000-meter level over Lindenberg (lat. 52°). From this result the assumption is permissible that the three to three and one-half year pressure oscillation in central Europe is dependent upon a periodic displacement of the equatorial front.

RAINFALL PROBABILITY DURING THE FIRE SEASON IN WESTERN WASHINGTON AND OREGON[1]

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If forest protective effort were adequate to absolutely prevent and suppress all forest fires, there would be less occasion to study quantitatively the hazards. But the funds are not adequate to give absolute protection. Hence protection has to be skimped in one region to bolster up that in another. The most intelligent distribution of resources in proportion to needs can be made only after some quantitative study of the several factors that go to make up fire danger.

It would help in the solution of the problem if each of the factors that go to make up the fire hazard could be measured and rated for each district—even for each tract of land. This is a goal to strive for—to measure and rate the inflammability based upon the amount and character of the combustible material on that tract, to estimate and rate the probability of fire starting, and then to rate the meteorological factors, the probability and local severity of low humidity spells, winds, and the chances of wetting rains, and put these elements together to make a fire danger index rating.

The present report—which is chiefly a set of graphs and maps [The latter not reproduced.—Ed.] aims to set forth in a preliminary way the rating of just one of the factors that contribute to the fire hazard—rainfall probability.

It has always been known that certain parts of this region had more summer rainfall than others, that some valleys were phenomenally dry, others so likely to have summer moisture as to be little worry to the protective agencies. This study was undertaken to find out what the Weather Bureau records might show as to summer rainfall at various points throughout western Oregon and Washington.

The results as presented in the graphs and maps will be of practical use to the protective agencies in getting a picture of one of the big underlying predisposing causes of forest fires, in seeing how much chance of rain they have to count upon in this locality as compared with that locality. They can better meet their opponent in the fire-fighting game if they know what the odds are against them.

It may be appreciated that the weather at any one station may in any one year be absolutely the reverse of the probability; i. e., these percentage chances of rain can not be used as indications of coming weather at any one station in any one period. These probabilities will be dependable over a term of years for a group of stations, just so far as the weather during series of past years is duplicated in the future.

Methods of making this study.—These were suggested by a paper read by Raphael Zon at Madison, Wis., in March, 1924, describing methods of drought prediction in Russia based on probabilities and entitled "Theory of probabilities in relation to climatic cycles as developed in Russia."

The present study consisted of assembling the United States Weather Bureau statistics for the region in such a way as to show how often during a term of years each station has had a good rain, a light rain, or no rain during each 10 days of the fire season. The printed records were used so far as they went, and beyond that the original records in the archives of the Portland and Seattle offices were consulted through the courtesy of Messrs. E. L. Wells and M. B. Summers. The compilation was performed by Mr. Louis Langdell.

All the stations in Western Oregon and Washington were used which had 10 or more years complete summer record. It so happened that there were exactly 50 such stations in each State. The compilation was prepared separately for each 10-day period from June 20 to September 10, which in the case of the last third of July and of August is actually an 11-day period. If a station in any 10-day period had 0.2 inch or more of rain in one or two days it was considered to have had a "wetting rain" or "good rain" in that period. This amount which has been used by other writers,[2] was selected arbitrarily as that which would subdue the forest fire menace for a few days. Recognition is given of the fact that the rate at which a rain falls and the type of cover it falls upon has much to do with its fire-deterrent effect. Ten-day periods which had a trace or more of rain but less than 0.2 inch in any two days were classed as having "light rains." If a station had no rain in a 10-day period it was so classified. The results of all the years, whether it be 10 years or 41, were assembled by 10-day periods for each of the 100 stations, and the percentage of times in each period that each station had "wetting rains," "light rains," or "no rains" calculated. Thus Government Camp, for the period August 1 to 10, in the 25 years of record had wetting rains 7 times, light rains 3 times, and no rain 15 times. This indicates a probability of wetting rains 28 times out of 100, light rains 12 per cent of the time, and no rains 60 chances out of 100.

Presentation of data.—The results of analyzing this great mass of meteorological statistics are assembled in the graphs shown on pages 396–397, one for Washington and one for Oregon. They show for each station what its chances are (based on its history) for a good rain, a light rain, and no rain, all given in percentages, for each of the 10-day periods.

[1] The term "rainfall probability" as here used connotes percentage frequency of rainfall of certain intensities; it should not be confused with results which may be deduced by the methods of the mathematical theory of probability.—Ed.

[2] Gisborne in "Measuring and Forecasting Forest Fire Danger in Northern Idaho" considers that ".20 inches or more in 24 hours is sufficient to eliminate fire danger in northern Idaho."

Some irregularities in the graphs may be due to very local unusual conditions or exposure if instrument at some stations. The reading of any single station must be considered with this in mind.

Before the analysis of past weather records was begun it was realized that for most stations the length of record was not sufficient to give accurate normals. It would have been better if all stations had 30 to 50 years record.

Furthermore, the records of the several stations are not for contemporary periods, and as there are wet cycles and dry cycles it is evident that a 15-year record running from 1910 to 1924 is not truly comparable with a 30-year record running from 1895 to 1924. To have used only those stations which had contemporaneous records for the same term of years would have reduced the number of stations and years used to a point that the compilation would have been meaningless.

Discussion.—The graphs speak for themselves and can be used direct without further analysis. They drive home vividly certain things it is well for all forest agencies to realize. For example, the coastal regions have much better probability of rain than the interior valleys, and the Cascade Range is wetter than the valleys but less so than the coastal belt. There is a progressive decrease in the chances for rain from north to south varying from a midsummer chance of 36 per cent in the northern Cascades to a 3 per cent in the southern. The acute shortage of rain begins earlier, is more intense, and lasts longer in the south, and this principle is true of the coast belt and Cascades as well as the valleys.

On the whole, western Oregon has a very much poorer chance of summer rains than western Washington. A comparison of the two States is presented in Table 1. The stations are very similarly distributed by physiographic regions in the two States, so that the comparison is fair.

Table 2 gives a comparison of the several physiographic regions of the two States and shows the marked contrasts that exist. It is compiled from the detailed entries by stations given in the graphs.

The periods of July 20–31 and August 1–10 are the worst of the season so far as lack of rainfall is concerned. The last 10 days of June and first 10 days of September are about the same in this regard. This does not check with the fire record because other factors than precipitation make the late August season the peak of the danger period, particularly the cumulative effect of the droughts, the seasonal maturing and withering of weeds, and the lowered moisture content of all vegetabtion and the increase in the human risk due to the vacation season. These factors tend to outweigh the slight increase in precipitation. If the graphs of one period be compared with those of another, it must be remembered that they are the picture of but one factor and not of the cumulative combination of all the elements of fire risks.

The graphic pictures of this one element of the weather should be used only within the limitations which this text specifies. If they help to acquaint the forest protective agencies with the customary seasonal and regional distribution of our fire-quenching showers they will have served the purpose for which they were intended.

TABLE 1.—*Chance of good rains and chance of no rains in the summer in western Oregon and in western Washington; average of 50 stations in each State.*

	June 20–30	July 1–10	July 11–20	July 21–31	Aug. 1–10	Aug. 11–20	Aug. 21–31	Sept. 1–10
	Chance of good rain, in percentage, through term of years							
Western Washington	69	49	39	26	24	48	46	72
Western Oregon	52	31	21	15	14	25	30	49
	Chance of no rain, in percentage, through term of years							
Western Washington	8	28	32	32	44	23	26	8
Western Oregon	25	45	52	54	63	47	40	30

TABLE 2.—*Chance of good rains in each region during the summer; averages of stations in each region*

	June 20–30	July 1–10	July 11–20	July 21–31	Aug. 1–10	Aug. 11–20	Aug. 21–31	Sept. 1–10
	Chances of good rains, in percentage, through a term of years							
Washington:								
North coastal	63	43	40	32	27	53	54	72
South coastal	76	46	41	33	24	49	39	80
East Olympic	62	43	33	17	22	44	44	51
Puget-Cowlitz	64	46	37	23	21	44	44	68
North Cascades	76	67	46	31	36	55	52	88
South Cascades	78	52	40	27	27	53	45	79
Oregon:								
North coastal	70	39	30	30	21	37	40	62
South coastal	54	27	20	9	14	17	30	50
Willamette Valley	56	30	16	11	13	19	30	48
Umpqua-Rogue	30	24	14	8	8	20	14	34
North Cascades	68	46	26	26	25	42	51	64
South Cascades	46	38	37	14	3	25	23	56

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WASHINGTON - West of Cascades

PROBABILITY OF GOOD RAIN, LIGHT RAIN, AND NO RAIN

By 10 day Periods during Forest Fire Season

LEGEND

- Probability of Good Rain i.e. .02 inches during 1 or 2 days during period.
- Probability of Light Rain i.e. less than .02 inches in any 2 rains during period.
- Probability of No Rain i.e. No rain whatever during period.

Figures indicate probabilities in percent.

REGION	NAME OF STATION	LENGTH OF PERIOD IN YEARS	JUNE 21-30	JULY 1-10	JULY 11-20	JULY 21-31	AUGUST 1-10	AUGUST 11-20	AUGUST 21-31	SEPTEMBER 1-10
NORTHERN COAST	CLEAR WATER	12								
	FORKS	13								
	PORT ANGELES	11								
	PORT CRESCENT	16								
	QUINAULT	13								
	TATOOSH ISLAND	20								
SOUTHERN COAST	ABERDEEN	29								
	LONE TREE	12								
	NORTH HEAD	21								
	SOUTH BEND	26								
EAST OLYMPIC	BREMERTON	22								
	GRAPEVIEW	17								
	PORT TOWNSEND	30								
	UNION CITY	14								
PUGET-COWLITZ VALLEYS	ANACORTES	27								
	BELLINGHAM	31								
	BLAINE	24								
	CENTRALIA	21								
	CLEAR BROOK	21								
	COUPEVILLE	21								
	EAST SOUND	12								
	EVERETT	10								
	GRAND MOUND	10								
	KENT	11								
	LA CENTER	25								
	MARIETTA	10								
	OLGA	33								
	OLYMPIA	29								
	PUYALLUP	11								
	SEATTLE	33								
	SEDRO-WOOLEY	26								
	SNOHOMISH	23								
	STATE UNIVERSITY	15								
	SUMNER	12								
	TACOMA	28								
	VANCOUVER	27								
	VASHON ISLAND	29								
NORTHERN CASCADES	CEDAR LAKE	14								
	DAVIS RANCH	14								
	GRANITE FALLS	21								
	LANDSBURG	15								
	SNOQUALAMIE FALLS	24								
SOUTHERN CASCADES	ASHFORD	13								
	BUCKLEY	12								
	KOSMOS	15								
	LONGMIRES SPRINGS	12								
	MOUNT PLEASANT	20								
	WIND RIVER	13								
	YACOLT	10								
	YALE	13								

OREGON - West of Cascades

PROBABILITY OF GOOD RAIN, LIGHT RAIN AND NO RAIN

By 10 day Periods during Forest Fire Season

LEGEND

Probability of Good Rain i.e. 0.2 inches during 1 or 2 days during period.

Probability of Light Rain i.e. less than 0.2 inches in any 2 rains during period.

Probability of No Rain i.e. No rain whatever during period.

Figures indicate probabilities in percent.